University of Zagreb
Faculty of Electrical Engineering and Computing

"Can we predict cardiac events? - Our experience on atrial fibrillation prediction after CABG"

Ratko Magjarević

First Symposium
"Toward translational research in brain and heart studies: Achievements and challenges in knowledge and technology transfer"
February 18, 2008, Zagreb, Croatia

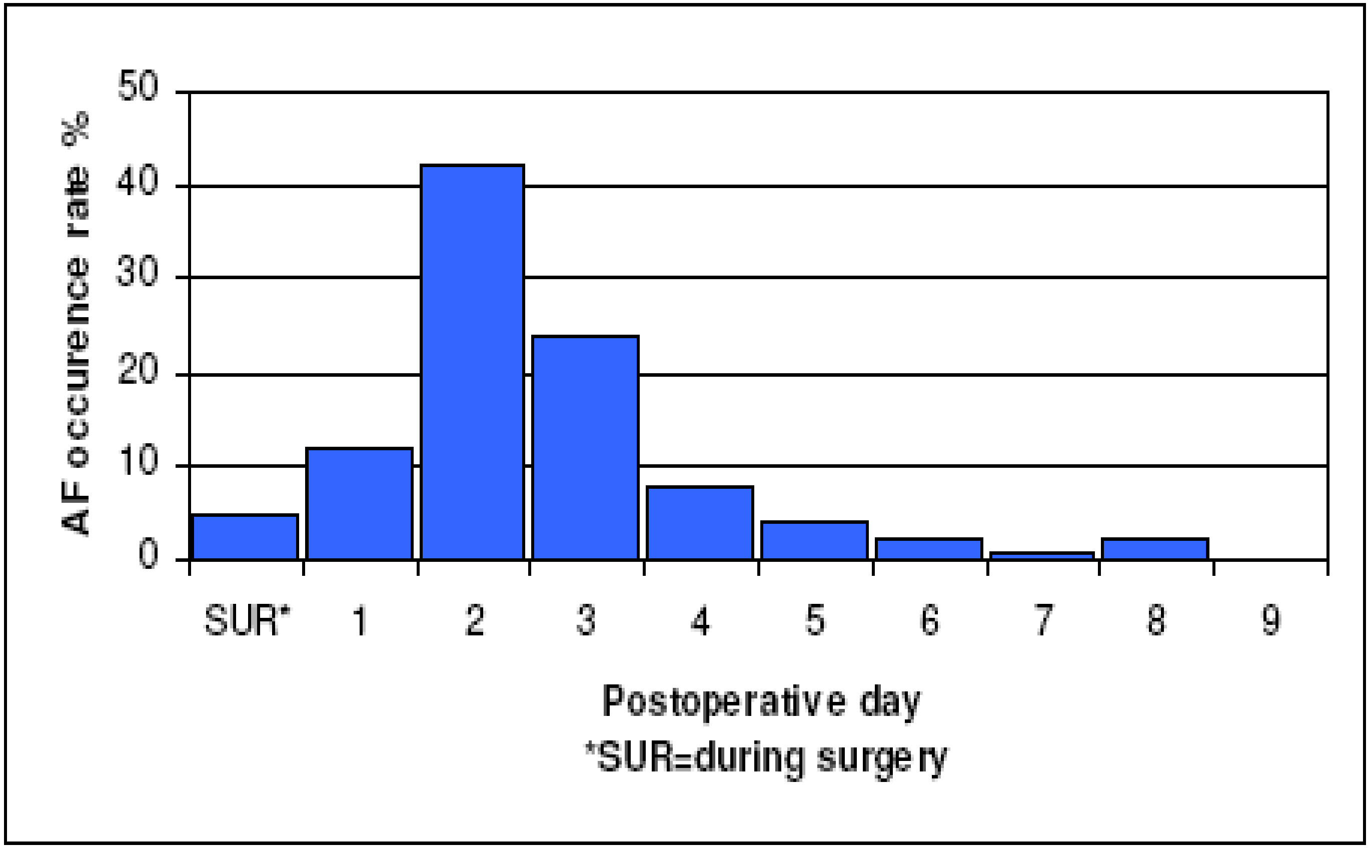
Introduction

- the aim of this study:
  - development of methodology and instrumentation for long- term study of ECG parameters
  - continuous monitoring of different P wave parameters in the group of patients after Coronary Artery Bypass Grafting (CABG)
  - examine potential predictors of atrial fibrillation

Atrial Fibrillation after CABG

- atrial fibrillation (AF) is the most common supraventricular arrhythmia that occurs in up to 40% of patients after CABG
- probable causative factors:
  - slow conduction and delay of conduction lines
  - inhomogeneous propagation due to the shortening and dispersion of atrial refractory period

The occurrence rate histogram for AF

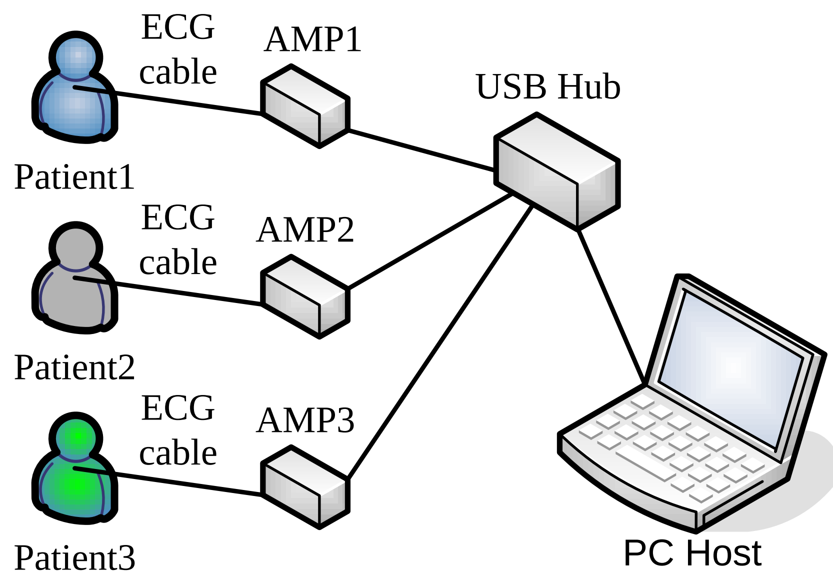


Methodes

- recording of lead II, standard surface ECG, period of typically 48 hours in patients after CABG
- dyadic wavelet transform analysis with first derivation of Gaussian smoothing function as a mother wavelet
- for every patient, for each 15 minutes period, vector of 88 P wave components was calculated

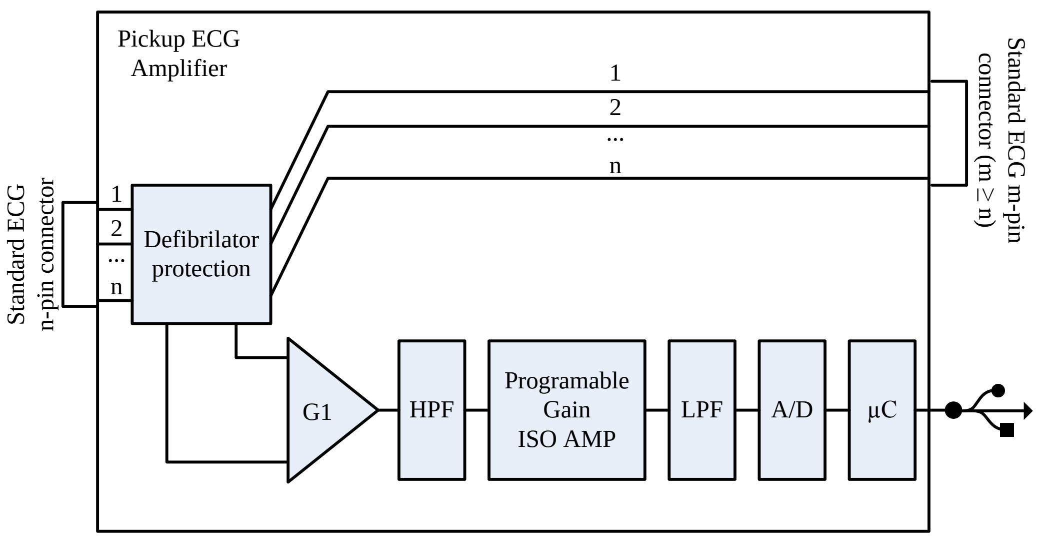
Data Acquisition

- Design and develop a simple ECG acquisition system
  - One PC as acquisition and storage device
  - Multiple pickup ECG amplifiers
- Connect the devices using USB
- Enable data acquisition from more than one patient at the same time
- Not to disturb normal ICU functionality



The ECG amplifier

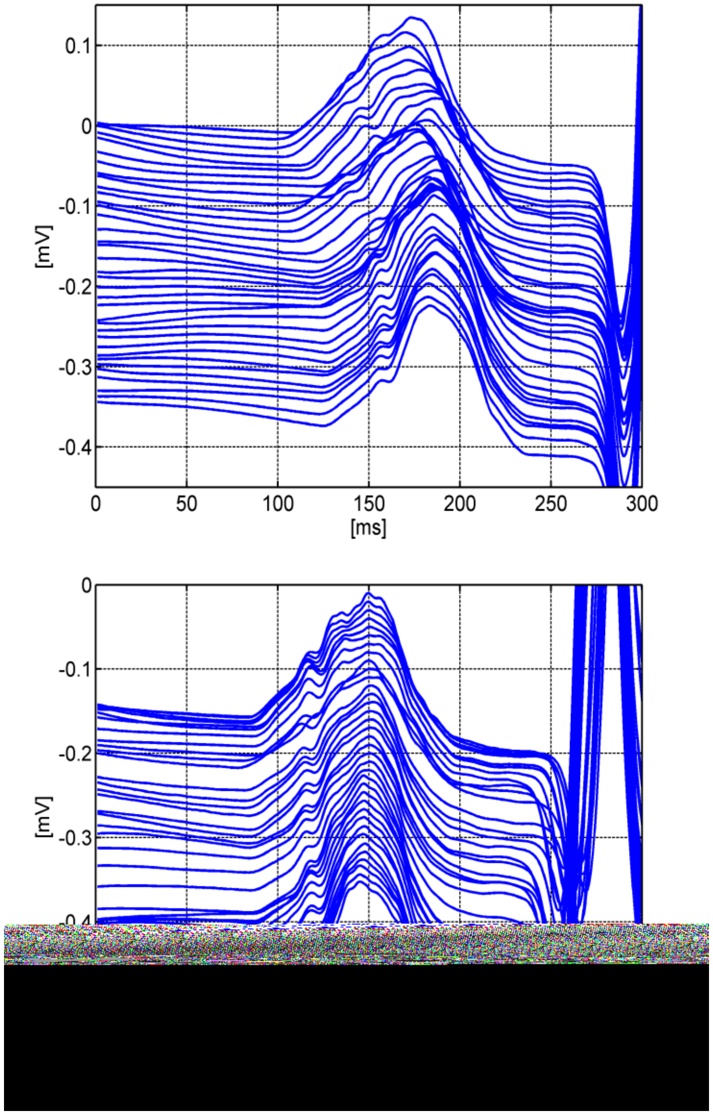
- Single channel ECG amplifier
- 4 gain values (200, 500, 1000, 2000) → automatically adjusted
- 16 bit ADC at 500Hz SR
- USB enabled microcontroller



- Input from a standard n-pin ECG connector
- Input signal transferred to m-pin standard ECG connector connected to ICU monitor
- One lead connected to acqisition and ADC hardware and sent to PC via USB

P-wave analysis

- continuous data acquisition
- ECG and P-wave parameters calculation (88 parameters)
- displaying provides physicians with an insight into processes that precede atrial fibrillation
- eg. successively aligned 300ms per hour averaged P-waves using R-wave or P-wave peak as the triggering signal

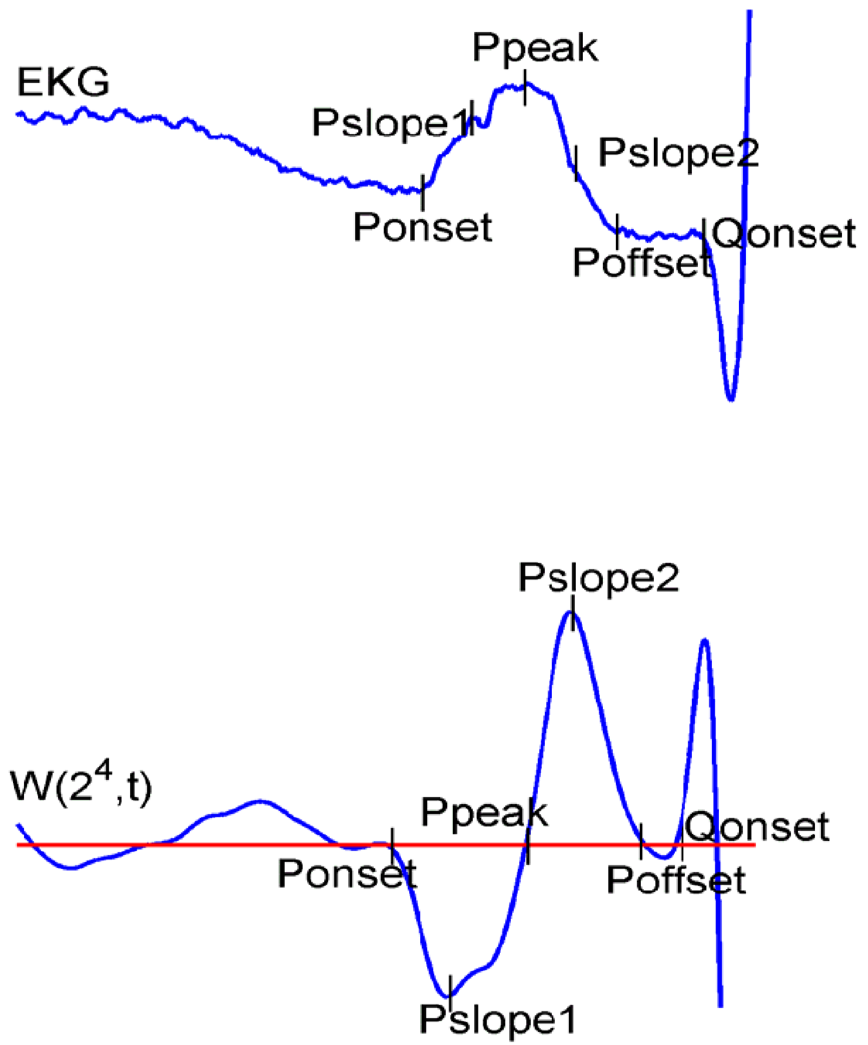


S. Sovilj, G. Rajsman, R. Magjarević: Classification Methosd for Atrial Fibrillation Prediction after CABG, MEDICON 2007.

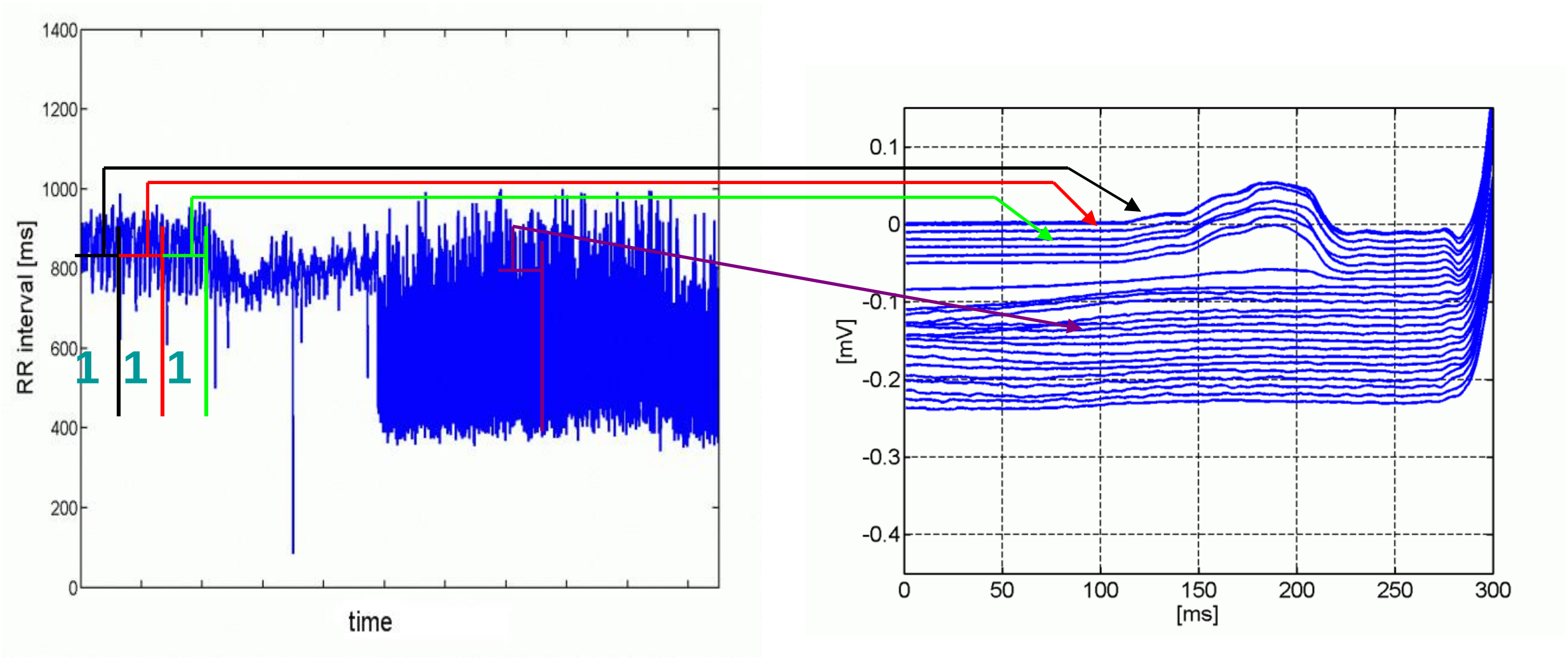
P wave parameters

- for every patient, in every hour, vector of 88 ECG, dominantelly P wave components was calculated, allowing continuous and deeper insight into atrial activity
- the aim was to record many different variables relating to patients' atrial activities in order to learn which variables best predict AF
- some of the parameters that were considered:
  - P wave duration
  - P wave amplitude
  - Surface area under the P wave
  - PR interval duration
  - PQ interval duration
  - Duration between points Pslope1 and Pslope2 at different scales
  - Value of wavelet coefficients Pslope1 and Pslope2 at different scales
  - RR interval duration (heart rate)
  - Absolute and relative wavelet energy at different wavelet scales
  - Wavelet entropy.........

The P wave segment of ECG, and the 4th scale of the wavelet transformation

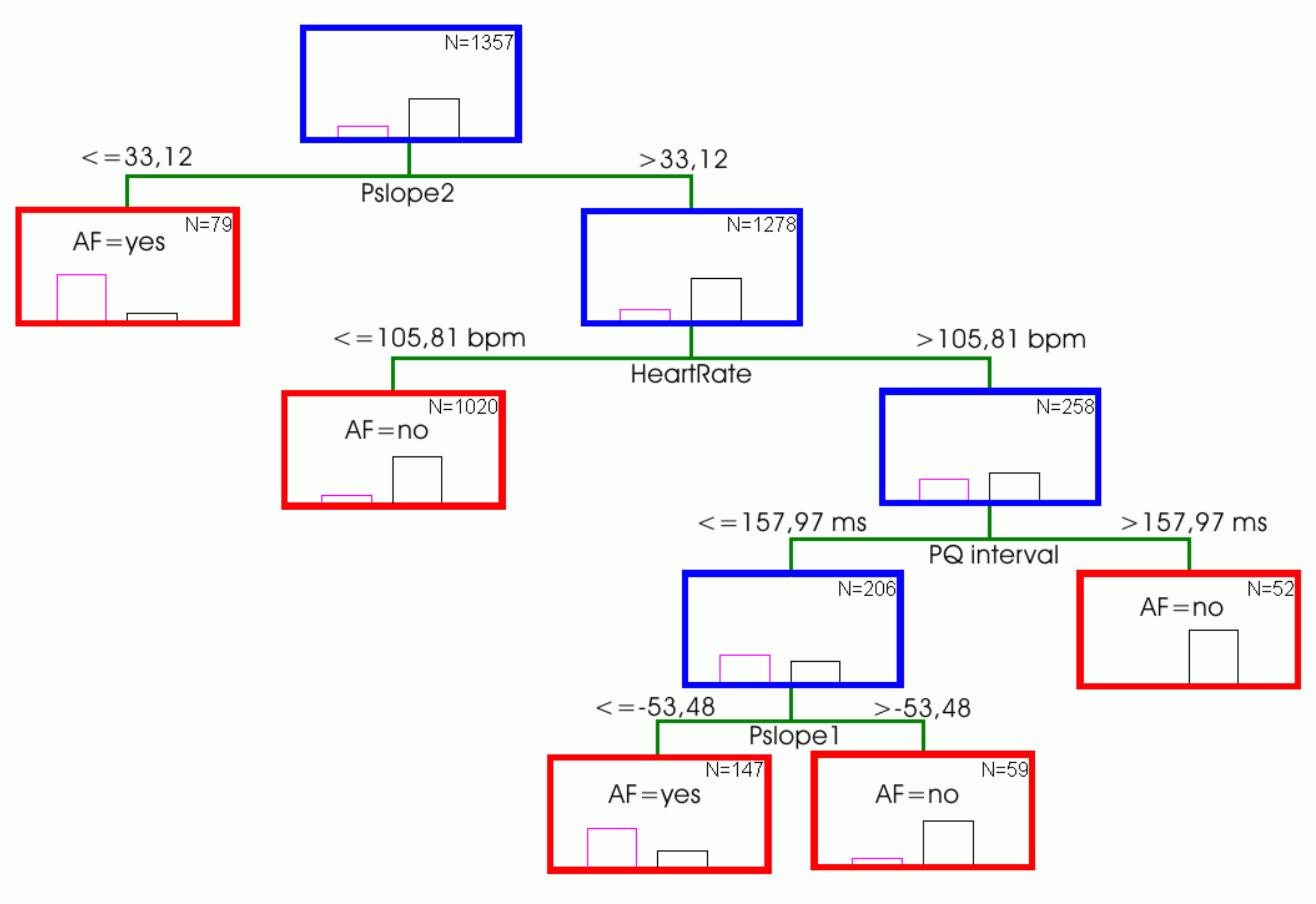


Atrial fibrillation



- Detection of AF predictors is marked with “1”

The classification tree (Model A)



Results

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Conclusions 1

- Automatic P wave detection enables
  - measurement and processing of the P wave parameters
  - continuous trend monitoring of different parameters over the recording period
  - extraction of clinically interesting information
- Continuous monitoring and trend presentation of multiple P wave parameters indicates changes in their trend before the appearance of atrial fibrillation
- This fact can be used in decision making for timely administration of anti-tachycardia therapy

How to include these findings into clinical practice?

- 1st step: building of stand alone peace of medical equipment
- 2nd step: integration of the algorithm into standard ICU monitors

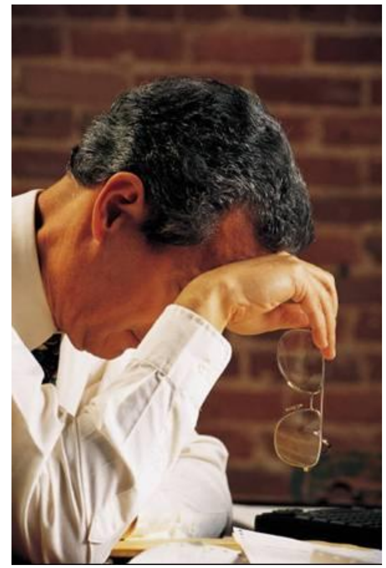
Current research

- Continous monitoring of multiple physiological parameters on mobile subjects by development of

  Personalized Health Body Area Network

Background

- Average age of population is increasing, especially in developed countries
- Rising demand for healthcare and other social services
- Prevalence of chronic diseases has increased
- Demand for the best available healthcare has extended
- Increased stress and workload - increased risks of diseases in younger population



Potential groups of users

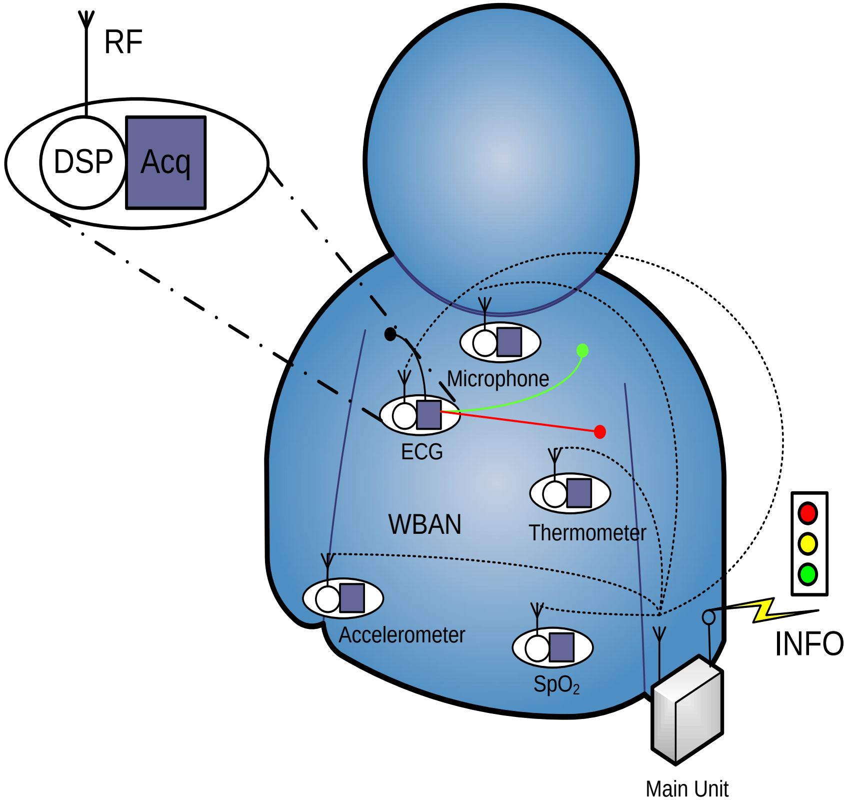
- Three potential groups of users:
  - *Chronically ill* – patients suffering from one or more diseases or have sustained a life threatening event
  - *Disease prone* – patients with risk factor in developing one or more diseases or life threatening events
  - *Volunteers* – healthy people that voluntary participate in healthcare and wellness programs in order to improve their well being

Objectives

- develop *Wearable sensors and sensor networks* for continuous monitoring of one or more physiological parameters
- develop algorithm for detecting serious health or life threatening situations
- develop a more intelligent system than the currently “popular” parameter measuring with no understanding
- transmit the information to the centre of care on a regular schedule
- integrate developed algorithms on the sensors integrated in the body network
- alarm users and supervisors of potentially dangerous situations and/or conditions

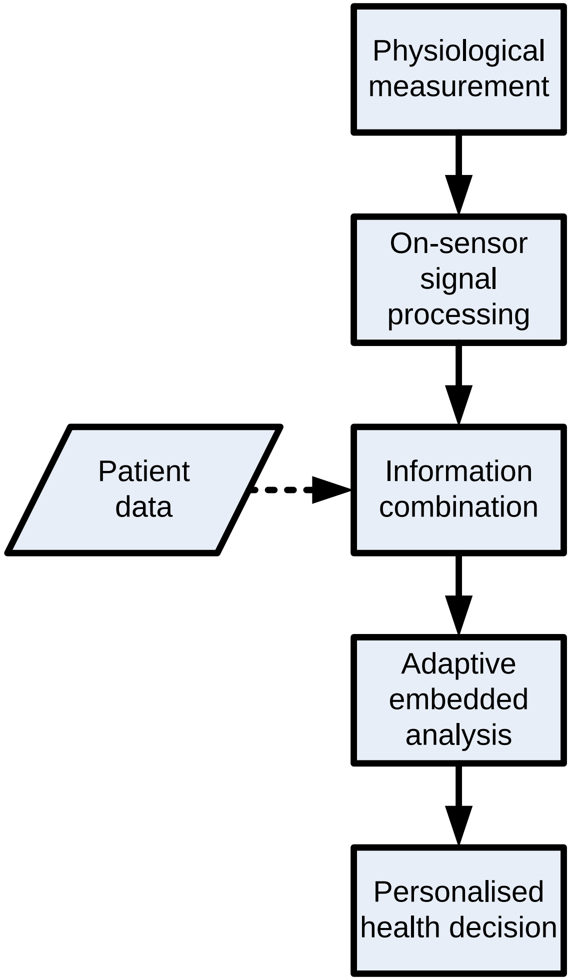
Body Sensor Network

- Parts of BSN:
  - main unit - server
  - series of sensors used for measuring and **processing** physiological parameters
- sensors connected to the main unit via wireless sensor network (e.g. ANT protocol)
- server unit communicating with the outside world
- BSN must not interfere with everyday activities of the users:
  - minimization,
  - comfort,
  - simple usage etc.

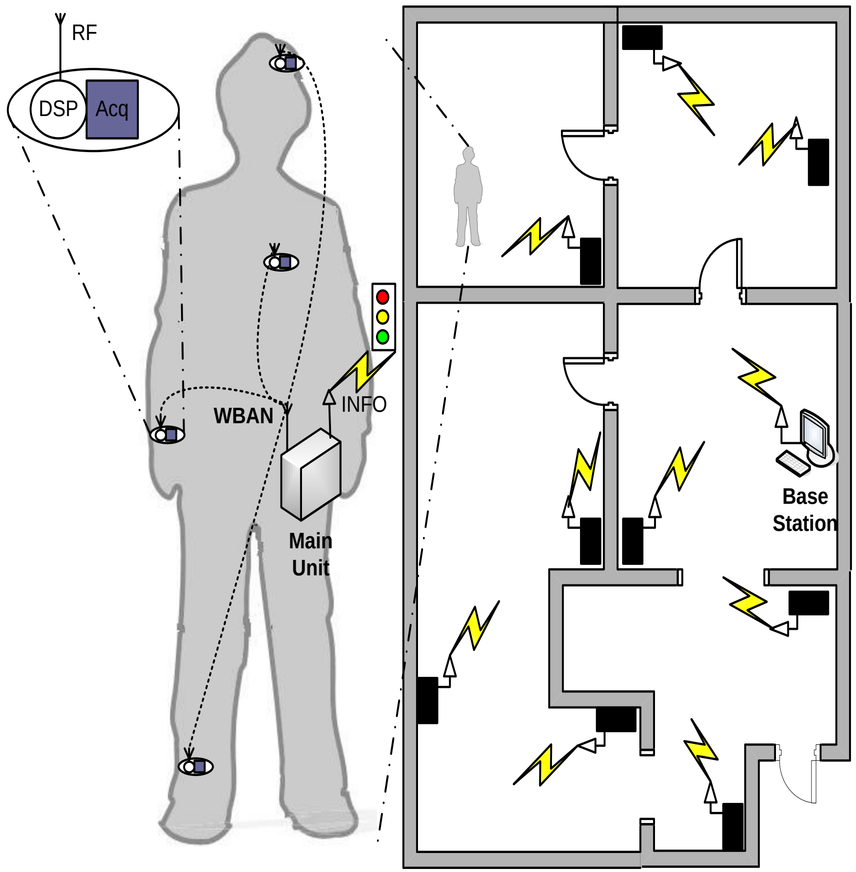


Individualized decision making process

- Multi step process
  - measurement of physiological parameters
  - signal processing on sensor units and detection of anomalies
  - integration of patient information and measured data
  - analysis by adaptive embedded algorithms
  - personalised health related decisions



Integration in an intelligent environment



- continuous monitoring of patients in confined spaces (hospitals, homes, offices, public transport...)
- use of wireless networks integrated in “intelligent environment”
- development of “ambient” sensors for detecting unwanted accidents (e.g. fall)

Conclusion 2

- developing networks for monitoring (only) of physiological parameters - popular and demanded
- currently there are no wearable solutions that can be used for independent decision making without consultations with medical staff
- Final goals:
  - improve healthcare,
  - improve quality of life,
  - enable independent living,
  - reduce the workload of the medical staff

“Antitumor electrochemotherapy, from the concept to the clinical practice”

26 March 2008, 6.30pm

Congress Centre, Children’s Hospital, Klaićeva 16, Zagreb

Program:

Introduction: prof.dr.sc. Ratko Magjarević, prim.dr. Egidio Ćepulić

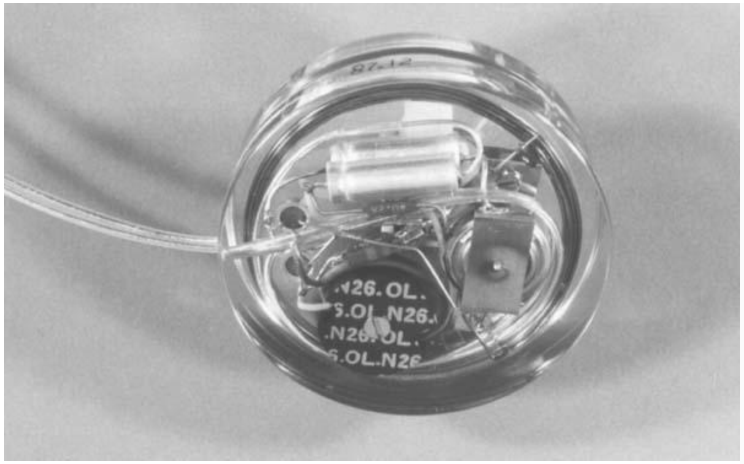
Prof.dr.sc. Damijan Miklavčič, Head of the Department for BioMedical Engineering, University of Ljubljana Faculty of Electrical Engineering

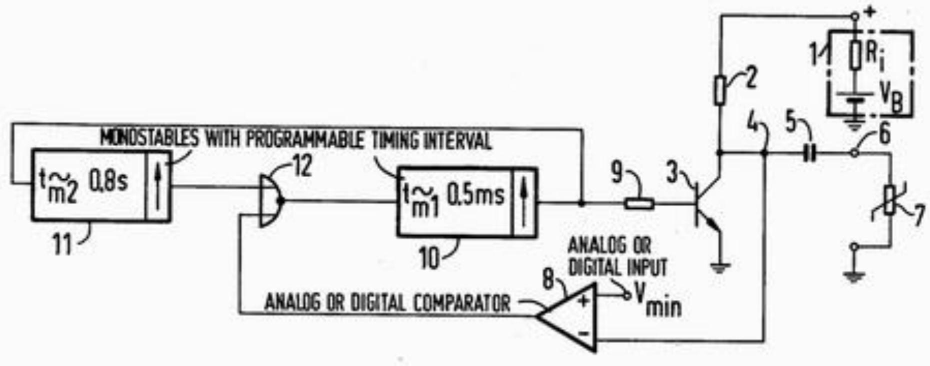
"Efficient in vivo electroporation"

Dr. Lluis M. Mir, Director of Research, UMR 8121 CNRS Institut Gustave-Roussy, Villejuif, France

"Biological basis and clinical results"

50 Years of the1st Pacemaker Implantation





- A success story – best ever therapeuthic device
- a number of events will be organized on the occasion of 50 years of the 1st pacemaker implantation